Maximum Input Signal of SQUID Feedback Amplifier

The required loop gain for a maximum input current i_{sig} to the fedback amplifier is

$$A_L = \frac{i_{sig}}{i_{SQ\max}} .$$

The maximum current to the SQUID input $i_{SQ\max}$ is determined by the mutual inductance M_i of the input coil to the SQUID loop

$$i_{SQ\max} = \frac{\Phi_0 / 4}{M_i} .$$

The feedback loop gain is determined by the amplifier gain A_{VA}, the SQUID's sensitivity $V_\Phi \equiv dV / d\Phi$, the mutual inductance, and the feedback resistance R_F

$$A_L = V_\Phi A_{VA} \frac{M_i}{R_F} .$$

The amplifier gain A_{VA} is required at the maximum signal frequency $f_{\max}$, so the amplifier's gain-bandwidth product

$$f_0 = A_{VA} f_{\max}$$

and the loop gain

$$A_L = V_\Phi \frac{f_0}{f_{\max}} \frac{M_i}{R_F} .$$

Combining this expression with the required loop gain $A_L = 4\frac{M_i i_{sig}}{\Phi_0}$ yields

$$4\frac{M_i i_{sig}}{\Phi_0} = V_\Phi \frac{f_0}{f_{\max}} \frac{M_i}{R_F} ,$$

so the required product of the SQUID sensitivity and the amplifier gain-bandwidth product

$$V_\Phi f_0 = 4\frac{i_{sig} f_{\max} R_F}{\Phi_0} .$$

Using peak output voltage V_P, the SQUID's sensitivity $V_\Phi = 2\pi V_P / \Phi_0$, the gain criterion becomes

$$\frac{V_P f_0}{R_F} = \frac{2}{\pi} i_{sig} f_{\max} .$$

The required product of the SQUID sensitivity and the amplifier gain-bandwidth product is independent of the SQUID's input mutual inductance. However, the intermodulation distortion depends on the loop gain, which does depend on M_i. Since $V_\Phi f_0 / R_F$ is set by $i_{sig} f_{\max}$, the loop gain can only be adjusted by choice of M_i.

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